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ABSTRACT

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The Relationships of Balance and Bilateral Coordination to Skipping in Kindergarten Children

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Abstract

The purpose of this study was to examine the relationship of balance and bilateral coordination to the fundamental locomotor pattern of skipping in 5– and 6–year–old children. Subjects were kindergarten students ($N = 30$) who were attending an elementary school in the suburban Kansas City area. The investigators used items from the Bruininks–Oseretsky Test of Motor Proficiency (Bruininks, 1978) to obtain balance and bilateral coordination scores. They used the Ohio State University Scale of Intra Gross Motor Assessment (O.S.U. SIGMA) for assessment of skipping performance. Based on results of correlational analyses, the correlation of balance and bilateral coordination—combined to skipping was significant ($p < .05$); correlations between balance and skipping and between bilateral coordination and skipping were not significant.

The Relationships of Balance and Bilateral Coordination to Skipping in Kindergarten Children

Motor development is an important component of child development and involves the underlying factors or processes influencing movement as well as movement itself (Gallahue, 1989; Haywood, 1986). Although the prevailing viewpoint is that motor development begins at conception, actually, movement is first observed at birth with reflexive and random movements, which stimulate maturation of the central nervous system (CNS). The maturing nervous system permits increasingly greater voluntary control over movement during the first year of life. Movement itself causes feedback to and from the central nervous system, thus contributing to refinement of motor control. With young children, movement skill development is the overt manifestation of CNS maturation.

Fundamental movement patterns are basic stabilizing, locomotor, or manipulative movements and consist of an organized series of related movements (Gallahue, 1989). Fundamental locomotor patterns are gross motor movements that propel the body from one place to another (Wickstrom, 1982). Skipping is the most difficult of these fundamental locomotor patterns and is the last to develop (Arnheim & Pestolesi, 1978; Gallahue, 1987; Gallahue, 1989; Haywood, 1986) because it requires a combination of two fundamental movement patterns and is highly dependent on neurological maturation. This sequence begins with crawling and creeping during the first year of life, followed by walking, running, jumping, galloping, sliding, hopping, leaping, and finally skipping.

Skipping is a basic fundamental locomotor pattern that most children acquire between the ages of five and seven, with more children able to skip with increasing age (Guttridge, 1939; Hottinger, 1980; Roberton & Halverson, 1984). Guttridge (1939) reported that 14% of 4–year–olds, 22% of 5–year–olds, and 90% of 6–year–olds could skip well, with a large variation in performance across the different age levels. Based on a sample of 98

children, Wellman (1937) described three stages of skipping and the motor age in months accompanying the stages: (a) shuffle—38 months, (b) skip on one foot—43 months, and (c) skip alternating feet—60 months. Wellman determined motor age to be the age at which 50% of the children performed the task correctly. Ulrich (1985) reported that 60% of subjects between 3 and 10 years of age ($N = 909$) could achieve established criteria in skipping by age seven. These criteria included: (a) rhythmical repetition of step–hopping on alternating feet, (b) nonsupport foot held near surface during hop phase, and (c) arms moving alternately at waist level in opposition to legs.

Skipping has been defined as a cross–extension movement of hopping, that is, a movement consisting of step–hops alternating on each foot to move the body forward (Arnheim & Pestolesi, 1978). Kirchner (1989) explained that the step component of the pattern is longer than the hop component. Roberton and Halverson (1984) described skipping as a "double–task pattern", i.e., each foot completes the step and hop before transferring weight to the other foot to complete the same task. This adds considerable complexity to the task. In addition, the arms move reflexively in opposition to the feet, and the movement is smooth and rhythmical. Skipping is a phenomenon which is something of a "Gestalt" experience because the whole is more than the sum of its parts. Something happens when the forward–upward and side–to–side movement pattern is combined with the quick three–beat rhythm of the skip—an integration of the parts into a new and unique mode of locomotion.

Because the skip is comprised of a step (walk) and a hop, we assumed that the skills prerequisite to skipping will develop first. One prerequisite skill and component part of skipping is hopping; therefore, children should be able to hop a number of times on either foot before they start alternating. Most children gallop and slide (i.e., gallop sideways) before they skip (Gallahue, 1987; Gallahue, 1989; Hottinger, 1980), and often children who do not know how to skip will gallop when asked to skip. Other children may attempt

a rudimentary type of skipping, a step–hop movement on one foot and walking on the other foot (Arnheim & Pestolesi, 1978; Gallahue, 1987; Wellman, 1937). In a developmental model of skipping, Roberton and Halverson (1984) hypothesized that following the one–footed skip, the second stage is a two–footed skip with a flat–footed landing on the hop (total foot or ball of foot–to–heel touching down before weight transfer). In the third stage of the developmental sequence, the landing from the hop is on the ball of the foot, at which time there is weight transfer to the other side of the body, with the center of gravity inclined more forward than in the second stage.

The difficulty of skipping lies not only with the necessity of alternating the step–hop sequence between both sides of the body but also with the timing of the weight transfer (Cratty, 1986; Roberton & Halverson, 1984). These factors involve bilateral coordination, which is the proficiency with which one uses the two sides of the body. It seems that delayed development of bilateral coordination would impede the child's ability to skip (Gesell, 1940; Kaufman, 1980).

Balance is the ability of the body to maintain equilibrium, and dynamic balance is the ability to maintain stability while the body is moving. Good balance skills are the foundation for movement skill development. Shambes (1976) explained that the integration of balance and voluntary movement is prerequisite to skilled movement execution. Subconscious equilibrium reactions "form the background upon which distal movements and skills are established" (p. 251). In order to maintain dynamic balance while hopping, the body leans slightly forward and over the support leg so that force can be directed through the center of gravity (Kirchner, 1989). Because hopping requires good dynamic balance, it is a skill of some complexity. The combination of stepping and hopping with repetitive shifting of weight from one foot to the other and back increases the difficulty of the task considerably (Andrews, Saurborn, & Schneider, 1960; Lockhart & Pease, 1966; Murray, 1975).

Despite the fact that skipping is a universal skill and is used in many movement and dance activities, little is known about the development of this skill (McClenaghan & Gallahue, 1978). Yet, skipping is often a component of many kindergarten readiness tests. Skipping appears to be an indicator of CNS maturity in young children. In order to assess ability of children to skip, it is logical to examine their balance and bilateral coordination. Because these functions are underlying factors to skipping performance, it is possible to base evaluations of skipping upon the demonstration of balance and bilateral coordination as well as on skipping itself.

A growing body of knowledge indicates that both balance and bilateral coordination are important indicators of the developmental process (Ayres, 1972, 1980; Pyfer, 1983; Quiros & Schrager, 1979). Two underlying processes of skipping—balance and bilateral coordination—are subtle indicators of motor development and are not as easily observed as skipping itself. Although balance is normally a subconscious act, it comes under voluntary control when it is measured in a testing situation. Bilateral coordination is a separate integrative function that is usually achieved by seven years of age (Ayres, 1972). Both of these underlying processes, balance and bilateral coordination, are motor control functions that are intrinsic to proper performance of skipping.

The purpose of this study was to determine the relationships of balance and bilateral coordination to the fundamental locomotor pattern of skipping in 5– and 6–year–old children with the hope that indepth study of the motor processes underlying skipping would provide further insight into the nature of the factors associated with this fundamental locomotor skill. This insight should enhance understanding of the phenomenon of skipping for teachers of young children. Hypotheses that relationships were not significantly different from zero were examined with the following variables: (a) balance and skipping, (b) bilateral coordination and skipping, and (c) balance–bilateral coordination (combined) and skipping.

Method

Subjects

All parents of children from two kindergarten classes at the same elementary school in suburban Kansas City were contacted regarding the study by means of a letter and accompanying permission form sent home from school with the children. All children from whom informed consent was obtained were included as subjects in the study. Subjects were 30 children whose ages ranged from five to six years. Gender composition of the sample included 19 male and 11 female children. No subjects displayed sensory, physical, or learning/mental disabilities. As ascertained by consultations with the principal and classroom teacher, all subjects were appropriately placed in the grade level.

Instrumentation

Skipping was evaluated using criteria outlined in the Ohio State University Scale of Intra Gross Motor Assessment (O.S.U. SIGMA) (Loovis & Ersing, 1979). This test for skipping is one of two assessment instruments designed to evaluate the process of the skill, and is suitable for use with primary grade children. The instrument is criterion referenced with four levels of development for each of the 11 gross motors skills. Content validity of the instrument was established by 11 motor development experts who rated the test on understandability and usefulness with a 5–point Likert–type scale, and by documentary analyses of the literature.

The investigators used items from the Bruininks–Oseretsky Test of Motor Proficiency (Bruininks, 1978) to measure balance and bilateral coordination. This instrument, normed for children between the ages of 5 and 14 years, has established validity and reliability and is also appropriate for use with primary grade children (Bruininks, 1978; Morris,Williams, Atwater, & Wilmore, 1982).

Procedure

The principal investigator tested subjects individually according to protocol of the

O.S.U. SIGMA and the Bruininks–Oseretsky tests, conducting testing on consecutive days of the same week. Each child was brought to the testing site, which was in an isolated multipurpose room. Preferred arm and leg were determined per instructions in the Bruininks–Oseretsky Examiner's Manual by throwing and kicking a tennis ball.

Balance performance was determined by using two balance tests, one static and the other dynamic. With the static balance test, Standing on Preferred Leg on Floor, subject stood on the preferred leg on a line, looking at a target, with hands on hips and the nonsupport leg bent so that it was parallel to the floor. The examiner demonstrated the criterion position and helped subjects achieve the correct position when necessary. The maximum score with this test was 10 s. With the dynamic balance test, Walking Forward Heel–to–Toe on Balance Beam, the subject walked forward heel–to–toe on the balance beam with hands on hips. The examiner demonstrated the criterion position and gave the subject verbal instructions. Maximum score was 6 steps.

The two bilateral coordination items both involved upper and lower extremities and opposite sides of the body. With Tapping – Foot and Finger Opposite Side Synchronized test, the subject simultaneously tapped the left index finger and right foot and then simultaneously tapped the opposite foot and finger. The subject was given 90 s to complete 10 consecutive foot/finger taps correctly. With Jumping in Place – Leg and Arm on Opposite Side Synchronized test, the subject jumped in place starting with the nonpreferred leg and opposite arm forward and preferred leg and other arm extended back, and jumping in place while reversing positions of arms and legs. Subject was given 90 s to complete 10 consecutive jumps correctly.

To measure skipping performance, each subject was shown two lines on the floor and asked to skip between them while being videotaped. The two lines ran the length of the room diagonally. The examiner determined that the subject understood the instructions, turned on the video camera, and the subject skipped the length of the room between the two

lines. The video camera was mounted to a tripod, and each subject was filmed from forward, sideways, and rear–sideways directions. Skipping performance was classified into one of the four developmental levels on the O.S.U. SIGMA test, with the maximum score as 4. Refer to Figure 1 for complete descriptions of test items used in this study.

Insert Figure 1 about here

Analyses of Data

Raw scores from the balance and bilateral coordination tests were transformed in order to establish a common scale for data analyses. This procedure was necessary because scoring procedures within the balance tests and between the two categories varied. The maximum scores for the static and dynamic balance tests were 10 s and 6 steps, respectively. For the bilateral coordination tests, maximum scores were 1 for each test.

For each balance test, scores were converted to numbers with a maximum high score of 100. Thus, the total balance score was the combination of the static and dynamic balance test scores, or a maximum of 200. The two bilateral coordination scores were combined in the same manner, with the maximum score limit as 200. The combined balance–bilateral coordination maximum score was 400.

Data were analyzed using mainframe computer facilities at the University of Kansas. Analyses included descriptive statistics on age and performance of the subject group. To test the hypotheses of the study, correlations were computed between the following variables: (a) skipping and balance, (b) skipping and bilateral coordination, and (c) skipping and balance–bilateral coordination (combined).

Results

Statistics describing age and performance of the two groups are presented in Table 1. Although age is expressed in months, the equivalent is five through six years. The mean

converted bilateral coordination score of .433 was unusually low because 21 of the 30 subjects scored zero on this test.

Insert Table 1 about here

Correlations were computed between combinations of variables to determine if significant relationships existed. The relationships of balance to skipping and bilateral coordination to skipping each yielded a correlation coefficient of .28. Neither correlation was statistically significant. The relationship of balance and bilateral coordination—combined to skipping produced a significant correlation ($r = .32$, $p < .05$). Although this correlation was statistically significant, the proportion of shared variance ($r^2 = .10$) was small according to Cohen's (1988) effect size index. Only 10% of the total variation can be explained by these correlated variables.

Discussion

Statistical analyses of data indicated that there were no significant relationships between balance and skipping, and between bilateral coordination and skipping. Results did show a significant relationship between the combined balance and bilateral coordination scores and skipping. According to Cohen (1988), the small effect size found in the present study ($r^2 = .10$) is typical of many relationships found in the behavioral sciences. Cohen explained that the correlation is weakened with the population even when hypothetically strong constructs exist because of operationalizing measurement and manipulating subjects.

Because no studies have been found with regard to balance and/or bilateral coordination and skipping and recent assessment instruments include more precise criteria for measuring skipping performance than the descriptive observations of research conducted in the 1930s, comparisons between the results of this study cannot be made with other research findings. In addition, because this study was exploratory in nature, results

should be viewed as a baseline for further indepth research in this area.

Skipping as the highest level fundamental locomotor skill requires both balance and bilateral coordination, in addition to combining elements of time, space, and force in a number of ways. An examination of the videotapes depicting the children's skipping performance showed that 26 subjects performed at Level III. These children did alternate feet, but many of them did so with deliberation and a manner of skipping that was stylized and exaggerated. Subjects either held their arms down at their sides, flexed at waist level, or swung them forward and backward in unison. In addition, subjects also demonstrated exaggerated lifting of knees and side–to–side movement, and their faces exhibited the intense concentration of someone learning a new skill.

This stylized skipping that is characteristic of Level III is a necessary step in the developmental process of learning to skip, but it is not true skipping. We observe a change from the somewhat fragmented, deliberate performance of skipping in Level III to the smoothly integrated uneven rhythm of the mature skipping pattern in Level IV. This tremendous improvement in skill level in skipping is an interesting phenomenon. Although skipping is one of the most significant motor milestones, the extent of its spontaneous development has not been thoroughly explained in the research literature or textbooks. However, we can clearly observe this developmental milestone in children, and we may recall experiencing it ourselves in learning motor skills involving Gestalt experiences.

Learning to ride a bicycle, which also involves a Gestalt experience, has similar underlying components to skipping and serves as an example. In the early stages, the child needs support from someone holding onto the bicycle so that he or she can concentrate on alternate foot pedaling and steering, without having to deal with the problems of maintaining balance. Often when the helper lets go of the bicycle the child is able to maintain balance for several feet, but both bicycle and child fall when the child leans too far to one side or stops pedaling. When the child begins to ride the bicycle without the aid of a

helper, he or she is able to pedal continuously in order to propel the bicycle but must concentrate on steering and transferring the body weight from side–to–side. Through trial and error, the child is not only able to steer and pedal the bicycle rhythmically but also to decrease side–to–side leaning of the body by means of finely tuned postural adjustments. In other words, the child learns to adapt body movement with increasing quickness and accuracy in response to ever–changing conditions without having to direct his or her attention to the mechanics of the task. The child's movement and postural adjustments then become virtually automatic in nature, and his or her attention can be directed to other factors in the environment. If the child is developmentally ready to ride a bicycle, learning progresses quickly and is usually mastered in a day or two. If the child is not developmentally ready for this skill, he or she will demonstrate fear, frustration, and failure.

The classroom and physical education teachers of the children participating in this study stated that they had worked very hard to teach the children how to skip. It may well be that the efforts of these well–intentioned teachers resulted in the children learning to skip as a "splinter skill". Kephart (1971) defined a splinter skill as a specific skill which is taught before the child is developmentally ready to learn it. According to Ayres (1972), gross motor skills do not develop until perceptual functions such as balance and bilateral coordination are firmly established. A splinter skill may be learned, but the child has difficulty generalizing and integrating the skill into his or her movement vocabulary. It is possible that this is the case with some of the subjects who exhibited poor performance in balance and bilateral coordination but scored at Level III on the skipping test.

In the kindergarten year, a developmental physical education program emphasizing perceptual–motor development (including locomotor patterns prerequisite to skipping) as suggested by Gallahue (1987, 1989) might be more beneficial to children than teaching skipping itself.. Both CNS maturation and readiness levels of the children to perform the

task should be considered prior to teaching skipping or, even, expecting a child to skip. Skipping as a specific activity would seem more appropriate for 7–year–old children. If teachers of young children continue to teach skipping to students before they are ready to learn it, then these children will not only be frustrated but also deficient in perceptual–motor development.

This study was undertaken to determine if there were significant relationships between two underlying processes of skipping—balance and bilateral coordination and the fundamental locomotor pattern of skipping in 5–and 6–year–old children. Results of the study indicate that, when balance and bilateral coordination scores are combined, there is a significant relationship but a small proportion of shared variance between these two individual underlying processes and the fundamental locomotor pattern of skipping. Neither balance nor bilateral coordination as separate factors correlated significantly with skipping. These results tend to support the "Gestalt" nature of skipping, i.e., the whole skill appears to be more than the sum of its parts.

In view of the dearth of research studies investigating the process of skipping and the underlying components of this skill, results of this study offer greater depth of understanding of the fundamental movement pattern of skipping and two contributing variables, at least with this sample of kindergarten children. Further research in the three areas should also include examination of fundamental locomotor skills prerequisite to skipping (i.e., galloping, sliding, and hopping) and a larger number of test items for balance and bilateral coordination. Additional research is necessary before definitive conclusions and generalizations regarding the process of skipping and the contribution of its underlying components can be made.

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Table 1

Description of Subject Group

Variable	Range (low–high)	M	SD
Age[a]	67–80	72.47	3.68
Skipping	2–4	3.07	.37
Balance[b]	97–200	167.87	32.90
Bilateral Coordination[b]	0–200	.43	.73
Bilateral Coordination and Balance[b]	97–400	211.20	91.84

[a]Measurement units are expressed in months.

[b]Represent converted scores.

Figure Caption

Figure 1. Description of instrumentation.

O.S.U. SIGMA--Skipping Performance (Loovis & Ersing, 1979)

Level I: The child cannot skip but will likely demonstrate any of the following behaviors:

1. running
2. galloping
3. hopping
4. leaping

Level II: The child attempts to skip while doing normal walking or running pattern and demonstrates the following behaviors:

1. performs skip more often than not on the same leg though not necessarily consecutively
2. holds arms either down at sides or slightly bent with hands at approximately waist level

Level III: The child skips and demonstrates the following behaviors:

1. alternates feet
2. does not use arms in opposition, if at all
3. does skipping pattern slowly, and it appears segmented (the child may walk or run for brief periods)

Level IV: The child skips and demonstrates the following behaviors:

1. alternates feet
2. uses arms in opposition (right arm forward when left leg is forward)
3. executes skip with ease and good coordination

Bruininks–Oseretsky--Balance Performance (Bruininks, 1978)

1. Standing on Preferred Leg on Floor test: Subject stands on the preferred leg on the walking line, looking at the target, with hands on hips and with the nonsupport leg bent so that it is parallel to the floor. The subject is told to hold that position for 10 s.
2. Walking Forward Heel–to–Toe on Balance Beam test: Subject walks forward on the balance beam heel–to–toe with hands on hips. The subject walks 6 consecutive steps in order to achieve a maximum score.

Bruininks–Oseretsky--Bilateral Coordination (Bruininks, 1978)

1. Tapping - Foot and Finger Opposite Side Synchronized test: Subject simultaneously taps the left index finger and right foot and then simultaneously taps the opposite foot and finger. Subject is given 90 s to complete 10 consecutive foot/finger taps correctly.
2. Jumping in Place - Leg and Arm on Opposite Side Synchronized test: Subject jumps in place, starting with the nonpreferred leg and opposite arm forward and the other leg and arm extended back. Subject jumps in place again, reversing positions of arms and legs and is given 90 s to complete 10 consecutive jumps correctly.